Fate of Arsenic in the Mahomet Aquifer: The Influence of Added Sulfate and Nitrate

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Material from the Mahomet aquifer, known to have pockets of high arsenic concentration, was evaluated for different microbiological activities that could influence the mobility of arsenic in groundwater. Project activities included a thorough assessment of core material collected in a region of the aquifer known for high arsenic concentration and flow-through column experiments evaluating the potential nature of arsenic mobilization in the subsurface.

Fresh core material was collected from a total of 25 intervals of Glasford aquifer sand, Mahomet aquifer sand, and till layers overlying the two aquifers. In order to determine the chemical form of arsenic in the sediments, samples from 8 intervals of the Glasford aquifer were chemically extracted using increasingly aggressive reagents. Arsenic was detected in at least one fraction for all extraction samples. The highest concentrations were found in the crystalline iron and manganese oxides fraction.

Biogeochemical reactions affecting arsenic concentrations in groundwater were evaluated using laboratory microcosms and column experiments. Microcosms containing core material, a small amount of acetate plus formate as electron donors, and either ferric iron or sulfate as electron acceptors, were prepared in order to evaluate the microbial activity potential associated with the aquifer sediments. After several months, additional electron donor and sulfate were added to evaluate the sustained ability of the reduction with different aquifer core materials. Terminal restriction fragment length polymorphism (T-RFLP) microbial community fingerprint analysis was used to show the differences between microbial communities.

Flow-through column experiments using sand coated with ferric-oxide and arsenate (As(V)) and inoculated with the iron-reducing bacterial culture were performed to better simulate conditions in an aquifer. The bacterial culture was developed from the active iron-reducing microcosms. Anaerobic filtered natural groundwater from the Mahomet aquifer was pumped through the columns at a rate of ~2 mL/day.

Microbially mediated ferric-iron reduction and sulfate reduction were observed in microcosms containing samples from all formations. In the column experiments, arsenate concentrations in the effluent were as high as 460 µg/L in the presence of the bacterial culture (vs. zero in control columns).

The experiments showed vertical spatial variability in microbial activity and bacterial community composition in aquifer sediments from both aquifers. Despite the very low natural sulfate concentrations, sulfate-reducing bacteria were uniformly distributed throughout both anoxic aquifers. This is consistent with a coexistence model for iron-reducing bacteria and sulfate reducers occurring in groundwater observed in other studies.

Column experiment results were surprising in the sense that although little or no iron-reduction activity was apparent by traditional ferrous iron analysis, arsenic release was dramatic once an inoculum was added. The column experiment appears to have changed the dynamic association between iron-reducing bacteria and the detection of ferrous iron; however, there appears to be little impact on the extent of arsenic release. Thus there appears to be a bacterial-mediated arsenic release that precludes its readsorption to the abundant iron-oxides remaining in the column.